

PATENT ABSTRACTS OF JAPAN

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(21)Application number : 03-230332 (71)Applicant : OKI ELECTRIC IND CO LTD

(22)Date of filing : 10.09.1991 (72)Inventor : NAGATA HIDEO
KIMURA YASUKI

(54) END POINT DETECTING METHOD IN ETCHING OF SEMICONDUCTOR DEVICE

(57)Abstract:

PURPOSE: To accurately detect the end point of etching by forming, under a film to be etched, a film which generates the light having the wavelength remarkably different from that of the film to be etched and then detecting the timing when the light having such wavelength is generated.

CONSTITUTION: A fluorocarbon film 6 is formed on a substrate 5 including the stepped area. Thereafter, a resist 7 and a mask 8 of O₂ RIE are formed on the fluorocarbon film 6. This fluorocarbon film 6 includes fluorine F having the peak of light emission in the wavelength of about 700nm which is remarkably different from 480nm which is the peak of light emission of an ordinary resist 7. A substrate 5 is set within an apparatus to conduct the etching and when the fluorocarbon film 6 is exposed, a light emitting intensity at 704nm of the fluorine F generated from the film 6 rises rapidly. Therefore this rise timing is measured. Therefore, even if a stepped area exists and an etching rate is ununiform, the end point of etching can be detected easily and accurately.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The example explanatory view of this invention

[Drawing 2] Change with a luminescence reinforcement [in O₂ RIE] of 704nm

[Drawing 3] The reactive ion etching system which carries out this invention

[Drawing 4] The example of change of the luminescence reinforcement of Poly-Si

[Description of Notations]

5 Substrate

6 Fluorocarbon Film

7 Resist

8 Mask of O₂ RIE

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the terminal point detection approach in the case of etching in manufacture of a semiconductor device, and reactive ion etching (O₂ RIE) of the organic material used for multilayer-structure resist lithography especially.

[0002]

[Description of the Prior Art] Although there are various approaches conventionally as the terminal point detection approach in the case of etching in manufacture of a semiconductor device, emission spectrometry is excellent in respect of dependability and economical efficiency, and is used. [many] this -- for example, reference: -- Takuo Sugano -- "a semi-conductor plasma process technique" -- it is indicated by the 1st edition and 2nd ** (Showa 57-6-27) Sangyo Tosho Publishing p.111-116.

[0003] Emission spectrometry is the technique of measuring luminescence according to the energy level of the atom in the plasma, a molecule, and ion as explained also to the reference.

[0004] Etching of the polish recon (it is described as Poly-Si below) film which formed membranes on the semi-conductor substrate is hereafter taken for an example, and the outline is explained.

[0005] Drawing 4 is drawing having shown a luminescence change of the example which carried out monitoring of the etching of Poly-Si using the Freon gas on the strength. As conditions, it is filter use with 3500Å of the thickness, gas:CF₄+O₂ (5%), pressure:0.35Torr, an RF BAWA:150W, and a measurement wavelength of 704nm.

[0006] If it does so, etching of Poly-Si will react so that it may be expressed with Si+4F* ->SiF₄ **. That is, F* after reaction initiation (fluorine radical) is F* in order to react with Si (silicon). Luminescence reinforcement (spectral intensity) decreases. And it becomes strong gradually as termination (ending point of etching of Poly-Si) is approached, and with termination, a reaction with Si is lost and it is saturated. such a phenomenon -- using -- F* from -- the terminal point of etching of Poly-Si is detectable by measuring luminescence reinforcement (this example luminescence reinforcement of 704nm).

[0007]

[Problem(s) to be Solved by the Invention] However, there are the following faults by the above-mentioned terminal point detection approach.

[0008] (1) Since the terminal point of etching does not become settled clearly when the substrate of the etched film is in a level difference condition (refer to drawing 1), or when an etch rate is uneven in a wafer (semi-conductor substrate) side, change of luminescence reinforcement (SUEKUTORU) becomes slow and the exact terminal point detection is difficult.

[0009] (2) Originally, although he wants to know correctly the time (that is, early stages of terminal) of a part of substrate being exposed, since it has a small change of luminescence reinforcement, detection of an etching terminal point is difficult.

MACHINE TRANSLATION

[0010] The above thing originates in disappearance of the terminal point of etching, i.e., the etched film, not taking place to coincidence, if it says collectively.

[0011] In order that the terminal point of etching described above may remove a difficult trouble, this invention improves the structure about the etched film, and aims at offering the approach which enabled exact terminal point detection.

[0012]

[Means for Solving the Problem] This invention is the film which produces luminescence of wavelength which the etched film is remarkable and is different under the etched film for the above-mentioned purpose implementation, and the etching property forms the etched film and the same film (for example, fluorocarbon film), and gets to know a terminal point by detecting the time of the luminescence occurring.

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[Function] Since this invention formed the film which produces luminescence of different wavelength under the etched film as mentioned above and it will go up quickly from the condition which does not almost have the reinforcement of luminescence from the etched film for detection that is, till then if it becomes an etching terminal point, it can do correctly that it is very easy to carry out the detection.

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[Example] The 1st example of this invention is shown in drawing 1, and it explains below.

[0015] This 1st example is an example of terminal point detection of etching of a multilayer resist. That is, that [film (etched film)] which is etched is the resist film.

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[0024] Next, although illustration is not carried out, the 2nd example of this invention is explained. It is the example applied to measurement of the sputter etching rate by O₂ RIE. An etching system uses the thing of drawing 3 mentioned above of course. However, in this example, the wavelength to measure has adopted 483.5nm which is luminescence from CO as mentioned later.

[0025] This 2nd example of the etched film is [SiO₂, W, Ti, etc.] mainly about 500Å things which carry out thickness formation and prepare a photoresist with a thickness of about 2 micrometers in the bottom of it about the inorganic film. Although the thickness of membrane formation differs so to speak, the location of drawing 1 and a resist is reverse structure. That is, a photoresist is formed in the bottom of the etched film as film of different wavelength from it. Therefore, measurement of said etch rate is etched film, such as said SiO₂ and W.

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[0028] In addition, it cannot be overemphasized that the film which forms membranes under the etched film is not what is restricted to the fluorocarbon used for this example or a resist. If it is the ingredient which carries out convenient luminescence for terminal point detection, it is good anything as a principle. For example, effectiveness with the same said of fluorocarbon is realizable.

[0029]

[Effect of the Invention] Since the film which produces luminescence of different wavelength from the film was formed in the bottom of the etched film according to this invention as explained above, the terminal point of the etching is detectable with the luminescence at the time of the first stage.

[0030] Therefore, it is contributing [even when a level difference exists in a substrate, and even when an etch rate is uneven, can detect the terminal point of etching easily and correctly, and]-to improvement [in the manufacture effectiveness of a semiconductor device], and the improvement in dependability of quality size.

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[0017] Many explanation will not be required since the etching system of drawing 3 is well-known. There is an inspection hole 2 in the reaction chamber which has electrodes 4 and 5 at a flank, and the emission spectrum meter 1 is formed in the neighborhood. As everyone knows, the processing puts a wafer on the base on cathode 4 (not shown), introduces gas (O₂), and etches by generating the plasma by impression of high frequency (RF). Spectrum change of the plasma light in a reaction chamber is introduced into the emission-spectrum meter 1 through an optical fiber, electric conversion of it is carried out, and, usually it acts as the monitor of the etching situation. this example -- F* from -- the luminescence reinforcement of 704nm was measured.

[0018] This example forms the about 500Å fluorocarbon film 6 first on the substrate 5 which has a level difference as an example, as shown in drawing 1 (a). This membrane formation is CHF₃. The plasma CVD by gas performs. Then, the mask 8 of a resist 7 and O₂ RIE is formed with a well-known technique on the fluorocarbon film 6.

[0019] Said fluorocarbon film 6 is F* generated from it. It has a luminescence peak near 700nm, and differs from 480nm order which is the luminescence peak of the ordinary resist 7 remarkably.

[0020] Although it etches by setting the substrate 5 in the equipment of drawing 3 mentioned above after forming membranes as mentioned above, the condition is shown in drawing 1 (b) and (c).

[0021] Conditions are O₂. Quantity of gas flow: It was referred to as 20sccm, pressure: 10mTorr, and RF Power: 200W.

[0022] Since a resist 7 does not have a big luminescence peak near 700nm as mentioned above, in the condition that the fluorocarbon film 6 is not exposed like drawing 1 (b), it is almost close to 0 (refer to the a-b part of drawing 2).

[0023] F* which will be generated from said film 6 if etching progressed and the fluorocarbon film 6 will be exposed like drawing 1 (c) from -- 704nm luminescence reinforcement starts quickly (c part of drawing 2). Therefore, when the resist 7 which is the time of the terminal point of etching beginning by measuring this standup, i.e., the etched film, is etched and the fluorocarbon film 6 of a substrate is exposed, it is correctly

MACHINE TRANSLATION

[very easily and] detectable.

[0024] Next, although illustration is not carried out, the 2nd example of this invention is explained. It is the example applied to measurement of the sputter etching rate by O₂ RIE. An etching system uses the thing of drawing 3 mentioned above of course.

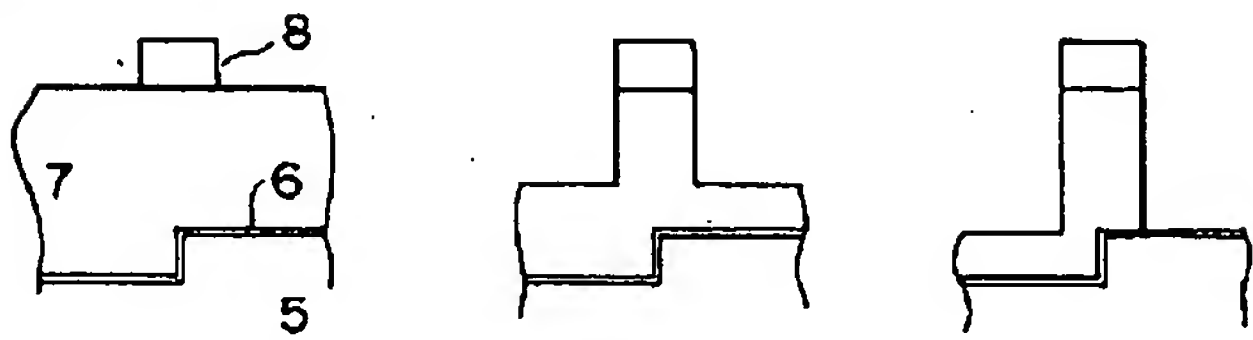
However, in this example, the wavelength to measure has adopted 483.5nm which is luminescence from CO as mentioned later.

[0025] This 2nd example of the etched film is [SiO₂, W, Ti, etc.] mainly about 500Å things which carry out thickness formation and prepare a photoresist with a thickness of about 2 micrometers in the bottom of it about the inorganic film. Although the thickness of membrane formation differs so to speak, the location of drawing 1 and a resist is reverse structure. That is, a photoresist is formed in the bottom of the etched film as film of different wavelength from it. Therefore, measurement of said etch rate is etched film, such as said SiO₂ and W.

[0026] Said measurement measures beforehand the thickness of the etched film of the object which measures a sputter etching rate first.

[0027] And although O₂ RIE is performed, if etching progresses and said resist is exposed, CO occurs from the resist film which is organic film, and the luminescence can be detected. That is, the terminal point of etching is detectable. Therefore, time amount until it is detected is measured, and if a division is done by the time amount of O₂ RIE which took initial thickness to detect luminescence from CO, said etch rate will be called for easily and correctly.

[0028] In addition, it cannot be overemphasized that the film which forms membranes under the etched film is not what is restricted to the fluorocarbon used for this example or a resist. If it is the ingredient which carries out convenient luminescence for terminal point detection, it is good anything as a principle. For example, effectiveness with the same said of fluorocarbon is realizable.



(a)

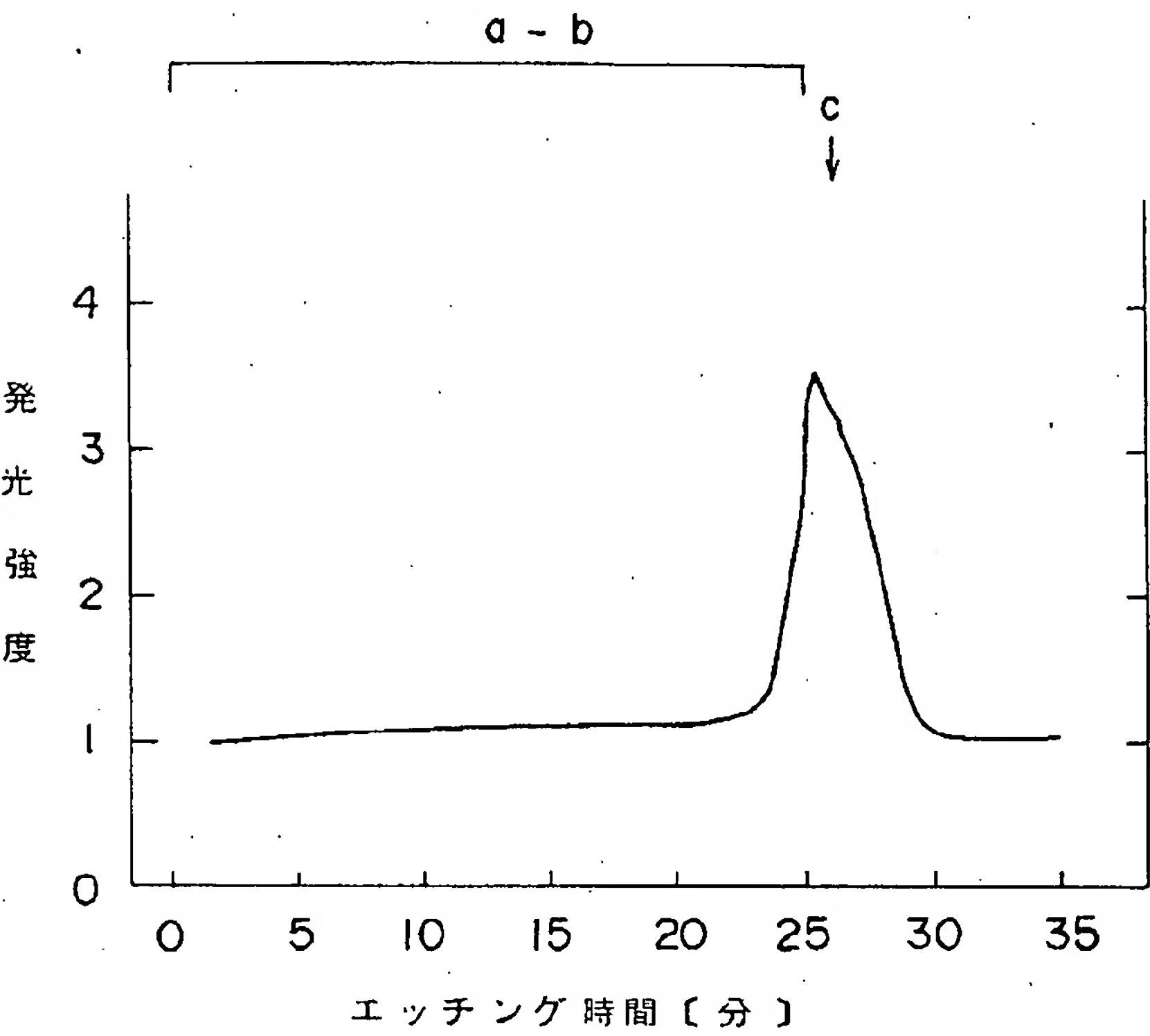
(b)

(c)

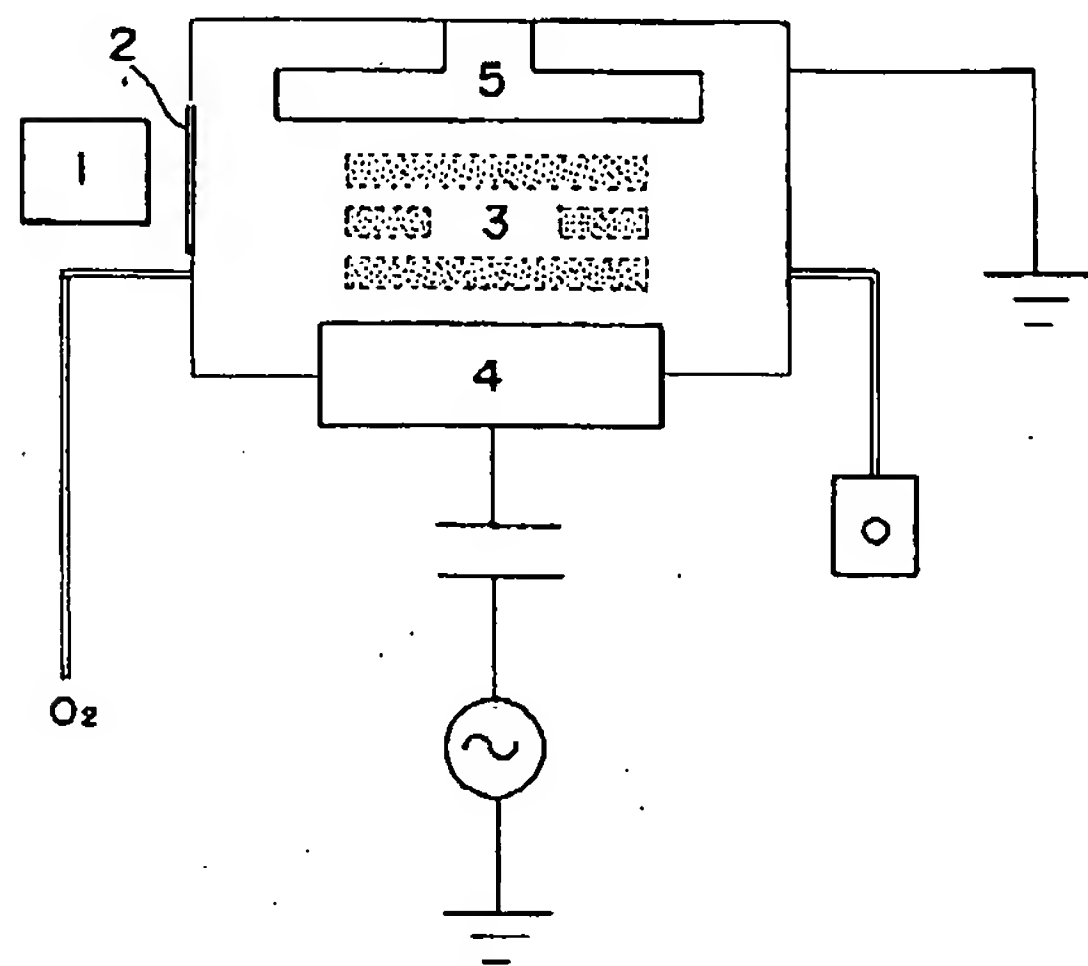
- 5: 基 板
- 6: フロロカーボン膜
- 7: レジスト
- 8: O₂RIE のマスク

本発明の実施例説明図

[Translation done.]



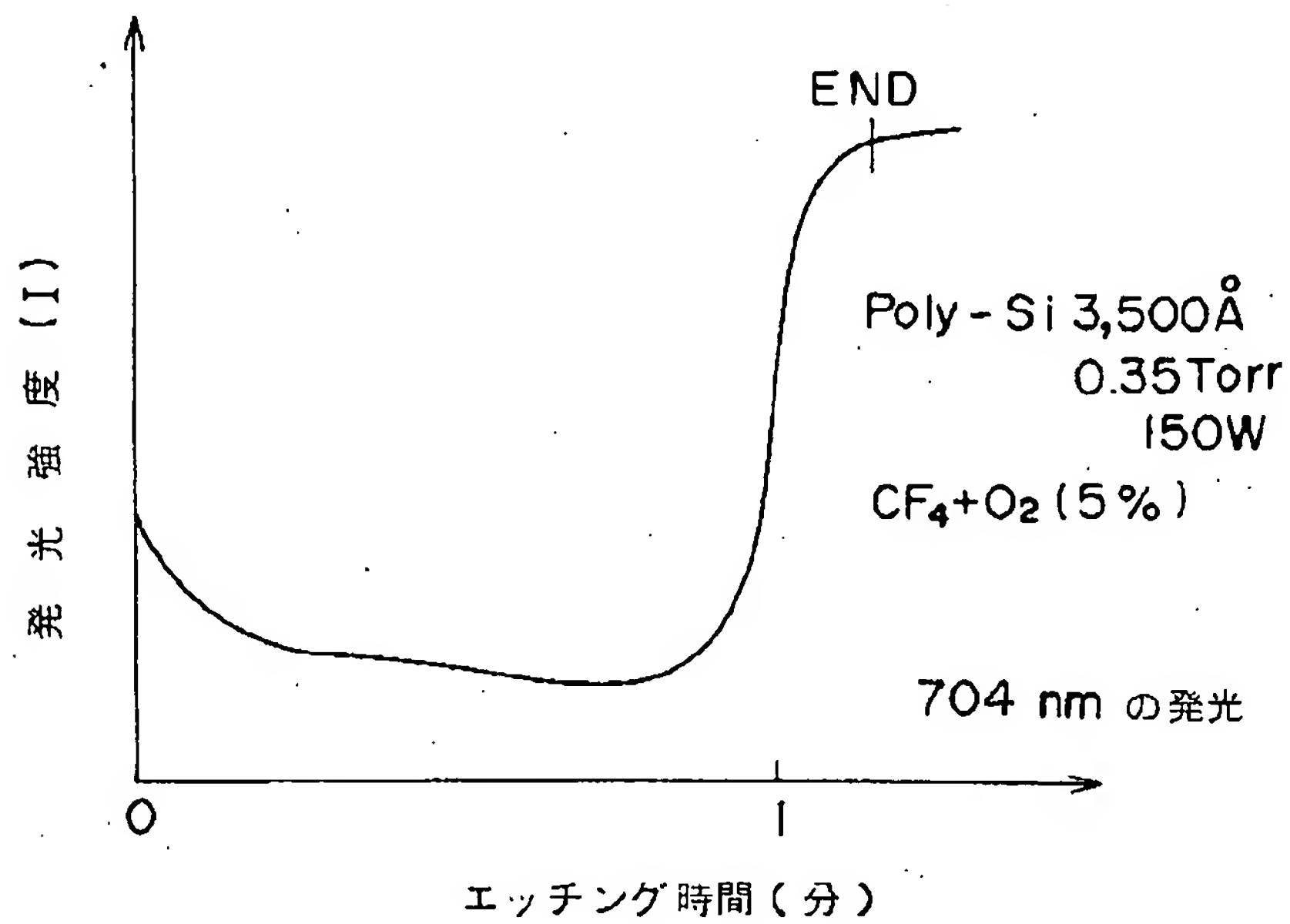
O₂RIE 中の 704 nm の発光強度の変化



- 1 : 発光スペクトルメータ
- 2 : 視 窓
- 3 : プラズマ
- 4 : 陰 極
- 5 : 上部電極

本発明を実施する反応性イオンエッチング装置

[Translation done.]



Poly-Si の発光強度の変化例

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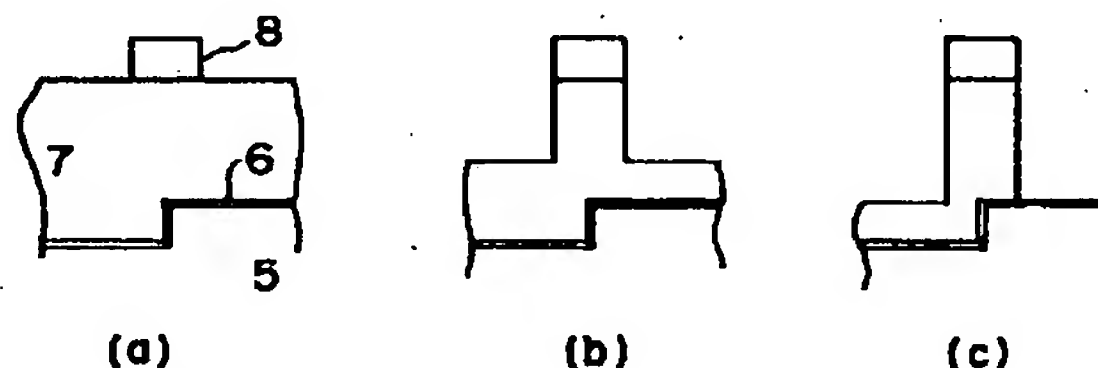
(74)代理人 弁理士 鈴木 敏明

(54)【発明の名称】 半導体装置のエッチングにおける終点検出方法

(57)【要約】

【目的】 本発明は、半導体装置の製造におけるエッチングの際のその終点検出を、より容易にかつ正確に行なう方法を提供することを目的とするものである。

【構成】 前記目的実現のために本発明は、被エッチング膜の下に、その被エッチング膜とは波長の異なる発光を生じる材料を成膜しておき、エッチングの終点、つまりその膜が露出した時点でその発光を計測することにより前記終点を検出するようにしたものである。



5: 基板
6: フロロカーボン膜
7: レジスト
8: O₂RIE のマスク

本発明の実施例説明図

6

【特許請求の範囲】

【請求項1】 半導体装置の製造におけるエッチングの際のエッチングの終点を検出する方法として、半導体基板上に形成する被エッチング膜の下に、あらかじめ該被エッチング膜とは異なる波長の発光を発生する材料の膜を成膜しておき、その膜からの発光を計測することにより前記被エッチング膜のエッチングの終点を検出することを特徴とする半導体装置のエッチングにおける終点検出方法。

【請求項2】 前記被エッチング膜とは異なる波長の膜を、フロロカーボン膜としたことを特徴する請求項1記載の半導体装置のエッチングにおける終点検出方法。

【発明の詳細な説明】

【0001】

【産業上の利用分野】この発明は、半導体装置の製造におけるエッチング、中でも多層構造レジストリソグラフィに用いられる有機材料の反応性イオンエッチング(O₂ RIE)の際の終点検出方法に関するものである。

【0002】

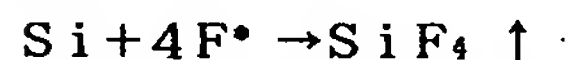
【従来の技術】従来、半導体装置の製造におけるエッチングの際のその終点検出方法としては種々の方法があるが、発光分光法が信頼性、経済性の点で優れており多く用いられている。このことは例えば文献：菅野卓雄「半導体プラズマプロセス技術」第1版、第2刷(昭57-6-27)産業図書p. 111-116に記載されている。

【0003】その文献にも説明されているように、発光分光法とは、プラズマ中の原子、分子、イオンのエネルギー準位に応じた発光を計測する手法である。

【0004】以下、半導体基板上に成膜したポリシリコン(以下Poly-Siと記す)膜のエッチングを例にとり、その概要を説明する。

【0005】図4はフロンガスを用いてPoly-Siのエッチングをモニタリングした例の発光強度変化を示した図である。条件としては、その膜厚3500Å、ガス：CF₄ + O₂ (5%)、圧力：0.35 Torr、RFパワー：150W、測定波長704nmのフィルター使用である。

【0006】そうすると、Poly-Siのエッチングは、



で表わされるように反応する。即ち、反応開始後F

・(フッ素ラジカル)はSi(シリコン)と反応するため、F[・]の発光強度(スペクトル強度)は減少する。そして、終了(Poly-Siがエッチングの終了点)に近づくに従い徐々に強くなり、終了とともにSiとの反応がなくなり飽和する。このような現象を利用して、F[・]からの発光強度(本例では704nmの発光強度)を計測することによってPoly-Siのエッチングの終

点を検出することができる。

【0007】

【発明が解決しようとする課題】しかしながら、前述の終点検出方法では以下のような欠点がある。

【0008】(1)被エッチング膜の下地が段差状態である場合(図1参照)、またはエッチング速度がウエハ(半導体基板)面内で不均一な場合、エッチングの終点が明確に定まらないため、発光強度(スペクトル)の変化が緩慢になり正確なその終点検出が困難である。

【0009】(2)本来エッチング終点の検出は、下地が一部露出した時点(つまり終点の初期)を正確に知りたいのであるが、それは発光強度の変化が小さいために困難である。

【0010】以上のことは、まとめて言えばエッチングの終点即ち被エッチング膜の消滅が同時に起こらないことに起因する。

【0011】本発明は、以上述べたエッチングの終点が困難な問題点を除去するために、被エッチング膜に関する構造を改良し、正確な終点検出を可能とした方法を提供することを目的とするものである。

【0012】

【課題を解決するための手段】本発明は前述の目的実現のために、被エッチング膜の下に、その被エッチング膜とは著しく異なる波長の発光を生じる膜で、かつエッチング特性は被エッチング膜と同様の膜(例えばフロロカーボン膜)を成膜しておき、その発光が発生する時点を検出することにより終点を知るようにしたものである。

【0013】

【作用】本発明は前述のように、被エッチング膜の下に異なる波長の発光を生じる膜を形成するようにしたので、エッチング終点になると、検出対象つまり被エッチング膜からの発光の強度がそれまで殆ど無い状態から急速に上昇するため、非常にその検出がし易くかつ正確にできる。

【0014】

【実施例】図1に本発明の第1の実施例を示し、以下に説明する。

【0015】この第1の実施例は、多層レジストのエッチングの終点検出の例である。つまりエッチングする膜(被エッチング膜)のはレジスト膜である。

【0016】図2はそのエッチングにおける発光強度の変化を示す図であり、図3は本実施例を実施するドライエッチング装置の概略図である。

【0017】図3のエッチング装置は公知のものであるから、多くの説明は要しないであろう。電極4、5を有する反応室には側部に覗き窓2があり、近辺に発光スペクトルメータ1を設けてある。周知のように、その処理はウエハを陰極4の上の台(図示してない)に載せ、ガス(O₂)を導入し、高周波(RF)の印加によりプラズマを発生させてエッチングを行なう。発光スペクトル

メータ1には反応室内のプラズマ光のスペクトラム変化を光ファイバーを通して導入し、それを電気変換してエッチング状況をモニターするのが普通である。本実施例では、F^{*}からの704nmの発光強度を計測するようにした。

【0018】本実施例は図1(a)に示すように、例として段差のある基板5の上に先ず500Å程度のフロロカーボン膜6を成膜する。この成膜は、CHF₃ガスによるプラズマCVDによって行なう。その後、フロロカーボン膜6の上にレジスト7とO₂RIEのマスク8を

公知の技術により形成する。
【0019】前記フロロカーボン膜6はそれから発生するF^{*}が700nm付近に発光ピークをもっており、普通のレジスト7の発光ピークである480nm前後とは著しく異なる。

【0020】前述のように成膜した後、前述した図3の装置内にその基板5をセットしてエッチングを行なうのであるが、その状態を図1(b)(c)に示す。

【0021】条件は、O₂ガス流量：20sccm、圧力：10mTorr、RFパワー：200Wとした。

【0022】前述したようにレジスト7は700nm付近には大きな発光ピークを持たないので、図1(b)のようにフロロカーボン膜6が露出しない状態では、殆ど0に近い(図2のa~b部分参照)。

【0023】エッチングが進んで図1(c)のようにフロロカーボン膜6が露出した状態になると、前記膜6から発生するF^{*}からの704nm発光強度は急速に立ち上がる(図2のc部分)。従って、この立ち上がりを計測することによりエッチングの終点が開始した時点、つまり被エッチング膜であるレジスト7がエッチングされ、下地のフロロカーボン膜6が露出した時点で、極めて容易にかつ正確に検出できる。

【0024】次に、図示はしないが本発明の第2の実施例を説明する。それはO₂RIEによるスパッタエッチング速度の計測に適用した例である。エッチング装置は無論前述した図3のものを使用する。ただし、この実施例では計測する波長は後述するようにCOからの発光である483.5nmを採用している。

【0025】この第2の実施例は、被エッチング膜はSiO₂、W、Tiなどの主に無機膜を約500Åの厚さ形成したものであり、その下に厚さ約2μmのホトレジストを設けるものである。いわば成膜の厚さは異なる

が、図1とレジストの位置が逆の構造である。つまり、被エッチング膜の下に、それと異なる波長の膜としてホトレジストを形成したものである。従って、前記エッチング速度の計測は前記SiO₂、Wなどの被エッチング膜である。

【0026】前記計測は、まずスパッタエッチング速度を計測する対象の被エッチング膜の厚さを、あらかじめ計測しておく。

【0027】そして、O₂RIEを行なうのであるが、エッチングが進み、前記レジストが露出すると有機膜であるレジスト膜からCOが発生しその発光が検出できる。即ちエッチングの終点が検出できる。従って、それが検出されるまでの時間を計測し、初期膜厚をCOからの発光が検出されるまでに要したO₂RIEの時間で除算すれば前記エッチング速度が容易にかつ正確に求められる。

【0028】なお、被エッチング膜の下に成膜する膜は、本実施例に使用したフロロカーボンやレジストに限るものではないことは言うまでもない。終点検出に都合のよい発光をする材料であれば原則として何でもよい。例えばフロロカーボンなどでも同様の効果を実現できる。

【0029】

【発明の効果】以上説明したように本発明によれば、被エッチング膜の下にその膜とは異なる波長の発光を生じる膜を形成したので、そのエッチングの終点をその発光により初期の時点で検出できる。

【0030】従って、下地に段差が存在する場合でも、またエッチング速度が不均一な場合でもエッチングの終点を容易にかつ正確に検出でき、半導体装置の製造効率の向上と品質の信頼性向上に寄与すること大である。

【図面の簡単な説明】

【図1】本発明の実施例説明図

【図2】O₂RIE中の704nmの発光強度の変化

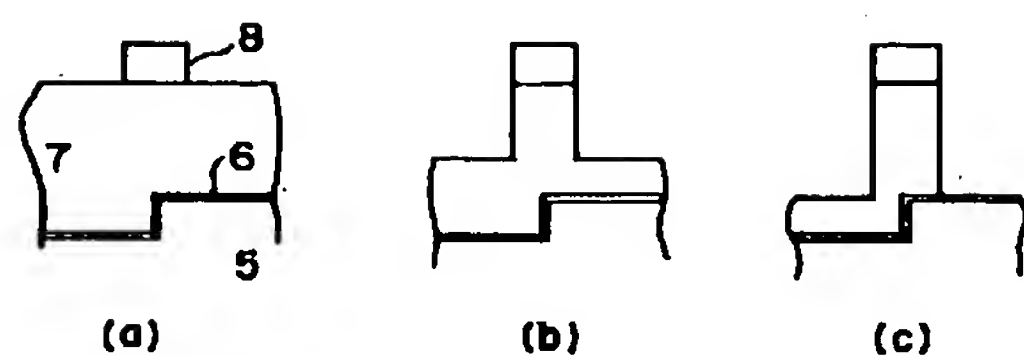
【図3】本発明を実施する反応性イオンエッチング装置

【図4】Poly-Siの発光強度の変化例

【符号の説明】

- 5 基板
- 6 フロロカーボン膜
- 7 レジスト
- 8 O₂RIEのマスク

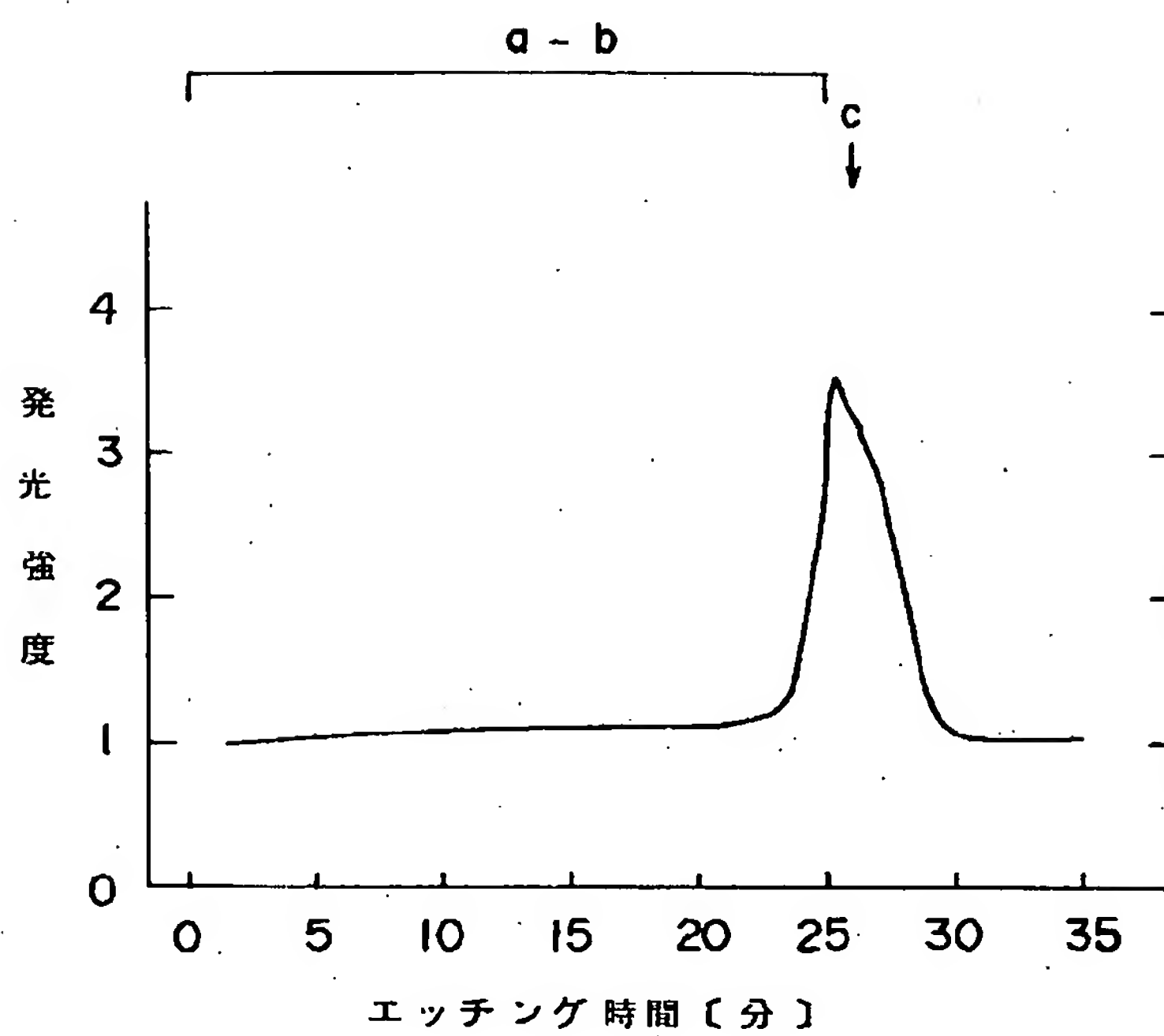
【図1】



5: 基板
6: フロロカーボン膜
7: レジスト
8: O₂RIE のマスク

本発明の実施例説明図

【図2】



O₂RIE 中の 704 nm の発光強度の変化

- 1: 発光スペクトルメータ
2: 環 窓
3: プラズマ
4: 腔 鏡
5: 上部電極

本発明を実施する反応性イオンエッチング装置

Graph showing the 704 nm emission intensity (発光強度 (I)) versus etching time (エッチング時間 (分)). The curve starts at a high intensity, decreases to a minimum, and then rises sharply to a plateau labeled "END".

Parameters:

- Poly-Si 3,500Å
- 0.35 Torr
- 150W
- CF₄+O₂ (5%)

704 nm の発光

Poly-Si の発光強度の変化例